

A3-Q3: Time of Death

```
In [1]: import numpy as np
        from scipy.integrate import solve_ivp
        import matplotlib.pyplot as plt
        import math
```

(a) Dynamics Function

```
In [2]: def TAmbient(t_total):
        t = t_total % 24

        if t > 7 and t <= 7.5:
            temp = 16 + (t - 7)/(7.5 - 7) * (22 - 16)
        elif (t > 7.5) and (t <= 19):
            temp = 22
        elif t > 19 and t <= 21:
            temp = 22 - (t - 19)/(21 - 19) * (22 - 16)
        else:
            temp = 16

        return temp
```

```
In [3]: def f(t, z): # z[0]: A  z[1]: B  z[2]: T
        dzdt = np.zeros(3)

        if z[2] >= 29 and z[2] <= 45:
            dzdt[0] = 0.0008*(z[2]-29)**2*(1-math.exp(0.08*(z[2]-45)))*z[0]*(30-z[0])
        else:
            dzdt[0] = 0

        if z[2] >= 17 and z[2] <= 32:
            dzdt[1] = 0.0001*(z[2]-17)**2*(1-math.exp(0.05*(z[2]-32)))*z[1]*(20-z[1])
        else:
            dzdt[1] = 0

        dzdt[2] = -0.1*(z[2]-TAmbient(t)) + (z[0] + z[1]) / 100

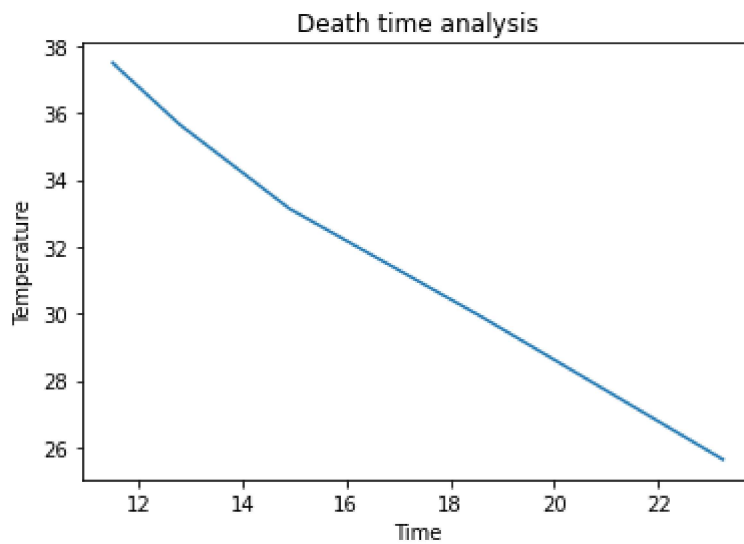
        return dzdt
```

(b) Run the simulation

```
In [4]: # The guess of the death time is 11:30 am
        y0 = [1, 1, 37.5]
        tspan = [11.5, 23.25]
        sol = solve_ivp(f, tspan, y0)
```

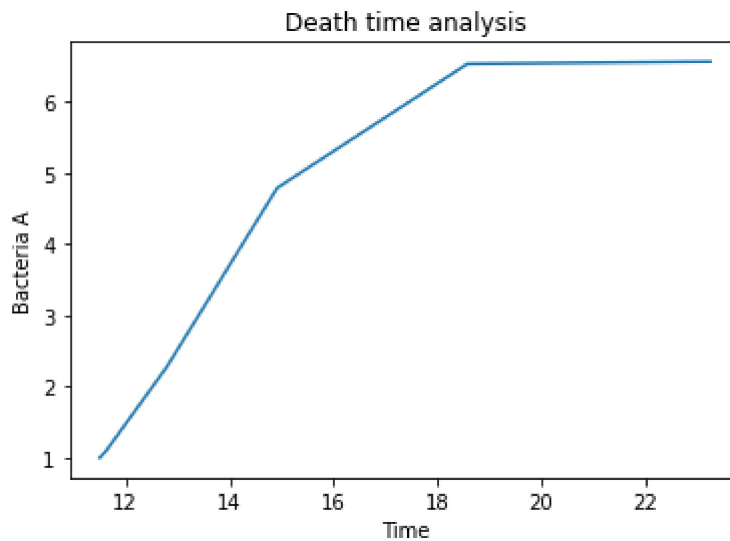
```
In [5]: plt.plot(sol.t, sol.y[2]);
        plt.title('Death time analysis');
        plt.xlabel('Time')
        plt.ylabel('Temperature');
        print("Final state at 11:15pm, T = " + str(sol.y[-1][2]))
```

Final state at 11:15pm, T = 35.64474708811936



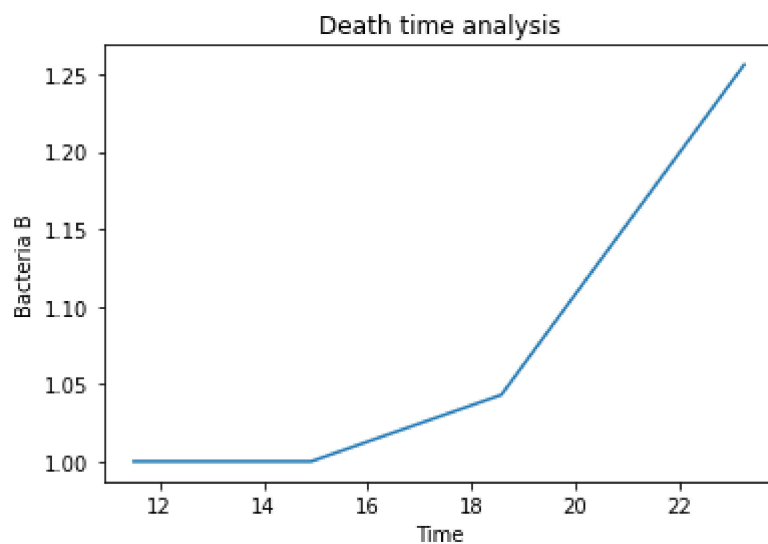
```
In [6]: plt.plot(sol.t, sol.y[0]);
plt.title('Death time analysis');
plt.xlabel('Time')
plt.ylabel('Bacteria A');
print("Final state at 11:15pm, A = " + str(sol.y[-1][0]))
```

Final state at 11:15pm, A = 37.5



```
In [7]: plt.plot(sol.t, sol.y[1]);
plt.title('Death time analysis');
plt.xlabel('Time')
plt.ylabel('Bacteria B');
print("Final state at 11:15pm, B = " + str(sol.y[-1][1]))
```

Final state at 11:15pm, B = 37.32055246374212



(c) Prime Suspect

Dennis Reader killed Robert Durst because only his alibi at 11:30am is unconfirmed.

In []: